# Total Interpretive Structural Modelling of Critical Factors of Sustainable-Oriented Innovation for Indian Manufacturing MSMEs


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**Abstract** The global integration of markets, rapid changes in technology and reduced lifecycles for product and technology have made the Micro, Small and Medium Enterprises (MSMEs) to focus on sustainability measures while considering innovation as an essential aspect to attain benefit in sustainable competition. Thus, the present study contributes to the empirical literature by finding out relationships between the critical factors which enhance the sustainable-oriented innovation for Indian manufacturing MSMEs. To this end, an exhaustive review of the literature and the opinion of the experts is taken, and a model is prepared using TISM technique to find the relationship between the factors. The outcome of the present study after applying total interpretive structural modelling technique is a framework which depicts the relationship between the factors influencing sustainable-oriented innovation for Indian manufacturing MSMEs.

**Keywords** Collaboration · Open innovation · Stakeholders · Total interpretive structural modelling

## 1 Introduction

The new understanding of innovation proposes that Micro, Small and Medium Enterprises (MSMEs) have an essential function in innovation [14]. The potential of MSMEs to provide employment in developing countries is very large. The proportion of MSMEs in Organisation for Economic Cooperation and Development (OECD) exports is about 25% and in exports from Asia is about 35% [26]. Innovation drives the competitiveness of a nation [8]. However, a more complex task is to maintain

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competitiveness as these firms are more vulnerable due to a variety of issues. These issues are more relevant for developing countries like India which to some extent is at a very low rank on the global competitive index (rank 40 amongst 137 participating nations) [32]. Keeping this in mind, present study targets at making a model to give structure to the factors that affect implementation of sustainable innovated practices for Indian manufacturing MSMEs as these firms contribution to the manufacturing output of the economy is more than 50% [9]. This is done using the TISM approach. The present study is carried out in the framework of the economy of a developing country like India. The northern part of India, i.e. Delhi NCR region is selected for the study as previous researches have focussed on the southern part of India. Various researchers [13, 25] have carried out the research limiting their research to identifying the critical factors focussing on Karnataka. Thus, the present study assumes significance as the focus is on Delhi NCR region.

In the present study, the definition of MSMEs is given with the focus on their aim in investing in plant and machinery only. Therefore, MSMEs comprise firms in the manufacturing sector and include those in automobile, electrical and machine tool enterprises which have a target of investing in plant and machinery which range from up to Rs. one hundred million as of 2006/07. It is in accordance with the statement of Micro, Small and Medium Enterprises Development Act, 2006 of the Government of India [10].

Innovation in present study mentions to technological innovation only. Technological product innovation is the application of a product with enhanced performance attributes in sustainability like as to give better services to the customer. Technological process innovation is the application of novel or enhanced producing or supply methods which is sustainable. It can cause modifications in facilities, personnel, working techniques or a blend of any two [20].

The present study thus aims to fill the gap in the literature on sustainable-oriented innovation for Indian manufacturing MSMEs by constructing a model of the factors influencing sustainable practices in Indian MSMEs. The remaining part of the paper advances in the following way: the next section contains a systematic study of the literature of the critical factors that helps in achieving sustainable-oriented innovation for Indian manufacturing MSMEs. A model is constructed using TISM technique. The results are examined along with managerial/practical implications of work. Finally, outcomes are derived, and limitations provided for future research.

## 2 Literature Review

A detailed systematic review of the literature is carried out to find out the critical factors which would influence the Indian manufacturing MSMEs in implementing sustainable-oriented innovation practices. Systematic literature review helps to get an overview of the existing work done by researchers in the field of sustainable-oriented innovation in MSMEs.

### 2.1 Integrating Stakeholders

Tyl et al. [30] in their paper have investigated the need for integrating the stakeholders in the green innovation process. A stakeholder is a human being or any organisation(s) that gets influenced by the process of the firm in either direct or indirect way. They are at a level where they can take the benefit from the 'value' and the 'goodness' from the product.

Various researchers [4, 31] in their studies have reported that giving value on the relations of the stakeholder is one of the essential components of organisation's strategy in moving towards sustainability.

### 2.2 Collaboration with Customer

Bhanot et al. [1] and Gupta and Barua [9] have studied the impact of interaction with the outside customer and the support given by them on enterprise innovation and concluded that networks which are strong create a positive influence on innovations and growth of the enterprise.

Subrahmanya [25] in his paper has emphasised that those organisations that do or do not have sufficient in-house resources can help them available external to the organisation.

### 2.3 Relationship with Suppliers

Subrahmanya [25] has suggested that the organisations that are having or not having sufficient in-house assets can add them with outside help and cooperation. This cooperation can take place concerning products or processes either occasionally or continuously with the help of suppliers or help from the consultants. De Marchi [6] has emphasised that in today's scenario, good relationship with the supplier has received greater importance. Collaboration with suppliers can be beneficial in reducing the overall environmental influence and ensuring eco-friendly attributes of inputs. De Marchi [6] acknowledges the relevance of the effect of networks of cooperation abilities amongst the determinants of environment-friendly technologies. In this aspect, a few studies ratify that cooperation of suppliers is vital driver of green innovation [6, 7, 9, 11, 12, 16, 25].

### 2.4 Open Innovation

Sag et al. [24] have pointed out that it has been found by the research that open innovation is useful for MSMEs to enhance their innovative activity, to satisfy the needs of the consumer quickly and to achieve environmental benefits.

A growing number of enterprises, especially MSMEs, rely more on outside knowledge and association done for research for carrying out innovation and gaining competitive advantages [5, 15, 17–19, 21].

### 2.5 Governance

Government initiatives are significant to implement sustainable-oriented innovation practices. The famous *Porter-hypothesis* [22] states that supportive Government for green initiatives can cause a win-win situation which can lead to reducing the pollution level and increasing the profit level.

Carrillo-Hermosilla et al. [3] report that innovations which are green are difficult to achieve as the Government, many times, can act as a barrier in the creating and adapting new system. Thus, benefits consisting of subsidies should be given by the Government for the growth of environmentally friendly activities.

Tang and Tang [29] point out that the enterprises should give acknowledgement to Governmental schemes. Efforts in the direction of sustainability should be seen as the long-term efforts because they require huge initial investment and yield profits in the long run [2, 16, 28].

### 2.6 Network with Universities

Network with the universities helps in academic–industrial collaboration. This helps the industries to incorporate new technologies, this provides the universities with the new topics of research, and they can also see the implementation of new technologies [33].

### 2.7 Help from Consultants

Consultants provide the firms with the expertise to carry out the research. They have expertise in particular fields which can be used by the firms in the implementation of new technologies [23].

### *2.8 Support from Technology Resource Centre*

Support from the technology resource centre acts as a catalyst in incorporating new technologies as they provide suitable training on the usage of new technology. They also provide support in terms of maintenance of new machines incorporated by the firms.

## 3 Solution Methodology

After the factors are identified, a model is constructed of the factors using the total interpretative structural modelling technique.

### *3.1 Total Interpretative Modelling Technique*

TISM is used as a tool of qualitative research which is used in the preliminary stages of problem solving to make a model of the factors [27]. This is done before applying statistical techniques, and the same can be applied to validate the model obtained through TISM technique. The steps to apply TISM are as follows:

(1) Identifying components: Identify components amongst which relationships are to be derived.
(2) Defining contextual relation: A very essential step is to define the contextual relation among the components. The same is shown in Table 1.
(3) Interpreting the relation: This is where the difference lies between the ISM and the TISM technique. TISM explains the relation between the two components. The same is depicted in Table 2.
(4) Interpretative Logic of Pair-wise Comparison: TISM technique allows giving reason behind the relationship between two components. If, for each paired comparison, the answer is 'Y', the reason is given.
(5) Reachability Matrix and checking of Transitivity: The comparisons made by pairing the contextual relations in the interpretive logic knowledge base are converted into reachability matrix by entering 1 in i-j cell, and if the equivalent entry in the knowledge base is 'Y' and in other case, write 0 in the entry.
(6) Level Partitioning on Reachability Matrix: It is carried out for placing the components level-wise.
(7) Develop Diagraph: The levels obtained are shown diagrammatically by making a model (Tables 3, 4, 5, 6 and 7).

**Table 1** Structural self-interaction matrix (SSIM) of critical factors

| Variable | C8 | C7 | C6 | C5 | C4 | C3 | C2 |
|---|---|---|---|---|---|---|---|
| C1 | A | X | V | V | X | A | V |
| C2 | A | A | V | X | A | O | |
| C3 | A | O | A | O | A | | |
| C4 | A | X | V | V | | | |
| C5 | A | A | V | | | | |
| C6 | A | A | | | | | |
| C7 | A | | | | | | |
| C8 | | | | | | | |

C1: Network with Universities; C2: Relationship with Suppliers; C3: Collaboration with Customer; C4: Help from Consultants; C5: Integrating Stakeholders; C6: Open Innovation; C7: Governance; C8: Support from Technology Resource Centre
V: Association in the direction of component i to component j and not vice versa
A: Association in the direction of component j to component i but not vice versa
X: Association in both the directions; component i to j and j to i
0 (zero), when the association among the components does not emerge to be accurate

**Table 2** Interpretive logic knowledge base

| S. No. | Element number | Y/N | In what way |
|---|---|---|---|
| C1: Network with universities | | | |
| 1. | C1–C2 | Y | This helps the suppliers to give their best quality raw material |
| 2. | C2–C1 | N | – |
| 3. | C1–C3 | Y | Transitive |
| 4. | C3–C1 | Y | Collaboration with customer enhances network with universities |
| 5. | C1–C4 | Y | Network with universities enhances help from the consultants |
| 6. | C4–C1 | Y | Help from the consultants increases when the firm has a good network with universities |
| 7. | C1–C5 | Y | It gives confidence to the stakeholder to take an active part in the decisions of the firm |
| 8. | C5–C1 | N | – |
| 9. | C1–C6 | Y | It has a positive influence on open innovation |
| 10. | C6–C1 | N | Open innovation can be carried out if the firm has a network with universities |
| 11. | C1–C7 | Y | It enhances support from technology resource centre |
| 12. | C7–C1 | Y | It encourages the support centre to give aid to the firm in the development of eco-friendly products |

(continued)

**Table 2** (continued)

| S. No. | Element number | Y/N | In what way |
|---|---|---|---|
| C2: Relationship with suppliers | | | |
| 13. | C2–C3 | Y | Transitive |
| 14. | C3–C2 | N | – |
| 15. | C2–C4 | N | – |
| 16. | C4–C2 | Y | It will improve the relationship with the suppliers |
| 17. | C2–C5 | Y | This relationship improves as the stakeholders will get confidence for investing in the firm |
| 18. | C5–C2 | Y | This relationship encourages the suppliers, and they work hard to give their best in terms of quality to the firm |
| 19. | C2–C6 | Y | This will positively influence open innovation |
| 20. | C6–C2 | N | – |
| 21. | C2–C7 | N | – |
| 22. | C7–C2 | Y | This support will influence the relationship with the suppliers |
| C3: Collaboration with customers | | | |
| 23. | C3–C4 | N | – |
| 24. | C4–C3 | Y | This help will aid in fulfilling the expectations of the customer |
| 25. | C3–C5 | N | – |
| 26. | C5–C3 | Y | Transitive |
| 27. | C3–C6 | Y | Transitive |
| 28. | C6–C3 | Y | Open innovation will help in meeting the expectations of the customer |
| 29. | C3–C7 | N | – |
| 30. | C7–C3 | Y | Transitive |
| C4: Help from consultants | | | |
| 31. | C4–C5 | Y | This will give confidence to the stakeholder |
| 32. | C5–C4 | N | – |
| 33. | C4–C6 | Y | It is a part of open innovation and hence will influence the same |
| 34. | C6–C4 | N | – |
| 35. | C4–C7 | Y | Help from the consultants will increase the support from technology resource centre |
| 36. | C7–C4 | Y | Help from support centres will also increase the help from consultants |
| C5: Integrating stakeholders | | | |
| 37. | C5–C6 | Y | Integrating stakeholders will enhance open innovation |
| 38. | C6–C5 | N | – |

(continued)

**Table 2** (continued)

| S. No. | Element number | Y/N | In what way |
|---|---|---|---|
| 39. | C5–C7 | N | – |
| 40. | C7–C5 | Y | This will give confidence to the stakeholders for investing in the firm |
| C6: Open innovation | | | |
| 41. | C6–C7 | N | – |
| 42. | C7–C6 | Y | Support from technology resource centre will enhance open innovation |

C7: Governance; C8: Support from Technology Resource Centre

**Table 3** Initial reachability matrix

| | C1 | C2 | C3 | C4 | C5 | C6 | C7 | C8 |
|---|---|---|---|---|---|---|---|---|
| C1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 0 |
| C2 | 0 | 1 | 0 | 0 | 1 | 1 | 0 | 0 |
| C3 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| C4 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 |
| C5 | 0 | 1 | 0 | 0 | 1 | 1 | 0 | 0 |
| C6 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 0 |
| C7 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 0 |
| C8 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |

**Table 4** Final reachability matrix

| | C1 | C2 | C3 | C4 | C5 | C6 | C7 | C8 |
|---|---|---|---|---|---|---|---|---|
| C1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 |
| C2 | 0 | 1 | 1 | 0 | 1 | 1 | 0 | 0 |
| C3 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 |
| C4 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 |
| C5 | 0 | 1 | 1 | 0 | 1 | 1 | 0 | 0 |
| C6 | 1 | 0 | 1 | 0 | 0 | 1 | 0 | 0 |
| C7 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 |
| C8 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |

## *3.2 Analysis of TISM*

From Fig. 1, it can be interpreted that good governance enhances the network with the universities as proper government initiatives promote academic–industrial collaboration. Good governance also promotes help from consultants and technology resource centres as they are being recognised by the government as change agents

**Table 5** Level partitioning level 1

| S. No. | Reachability set | Antecedent set | Intersection set | Level |
|---|---|---|---|---|
| 1. | 1, 2, 3, 4, 5, 6, 7 | 1, 3, 4, 6, 7, 8 | 1, 3, 4, 6, 7 | |
| 2. | 2, 3, 5, 6 | 1, 2, 3, 4, 5, 7, 8 | 2, 3, 5 | |
| 3. | 1, 2, 3, 4, 5, 6, 7 | 1, 2, 3, 4, 5, 6, 7, 8 | 1, 2, 3, 4, 5, 6, 7 | One |
| 4. | 1, 2, 3, 4, 5, 6, 7 | 1, 3, 4, 7, 8 | 1, 3, 4, 7 | |
| 5. | 2, 3, 5, 6 | 1, 2, 3, 4, 5, 7, 8 | 2, 3, 5 | |
| 6. | 1, 3, 6 | 1, 2, 3, 4, 5, 6, 7, 8 | 1, 3, 6 | One |
| 7. | 1, 2, 3, 4, 5, 6, 7 | 1, 3, 4, 7, 8 | 1, 3, 4, 7 | |
| 8. | 1, 2, 3, 4, 5, 6, 7, 8 | 8 | 8 | |

**Table 6** Level partitioning level 2

| S. No. | Reachability set | Antecedent set | Intersection set | Level |
|---|---|---|---|---|
| 1. | 2, 4, 5, 7 | 4, 7, 8 | 4, 7 | |
| 2. | 2, 5 | 2, 4, 5, 7, 8 | 2, 5 | Second |
| 4. | 2, 4, 5, 7 | 4, 7, 8 | 4, 7 | |
| 5. | 2, 5 | 2, 4, 5, 7, 8 | 2, 5 | Second |
| 7. | 2, 4, 5, 7 | 4, 7, 8 | 4, 7 | |
| 8. | 2, 4, 5, 7, 8 | 8 | 8 | |

**Table 7** Level partitioning level 3

| S. No. | Reachability set | Antecedent set | Intersection set | Level |
|---|---|---|---|---|
| 1. | 4, 7 | 4, 7 | 4, 7 | Third |
| 4. | 4, 7 | 4, 7 | 4, 7 | Third |
| 7. | 4, 7 | 4, 7 | 4, 7 | Third |
| 8. | 8 | 8 | 8 | Fourth |

in the implementation of sustainable-oriented innovation in Indian MSMEs. Network with universities, help from consultants and support from technology resource centres drive the relationship with suppliers and stakeholders. This helps to achieve open innovation and enhances the collaboration with customer. Innovation which is carried out by the exchange of ideas and by interacting with the customer influences sustainable-oriented innovation in manufacturing MSMEs.

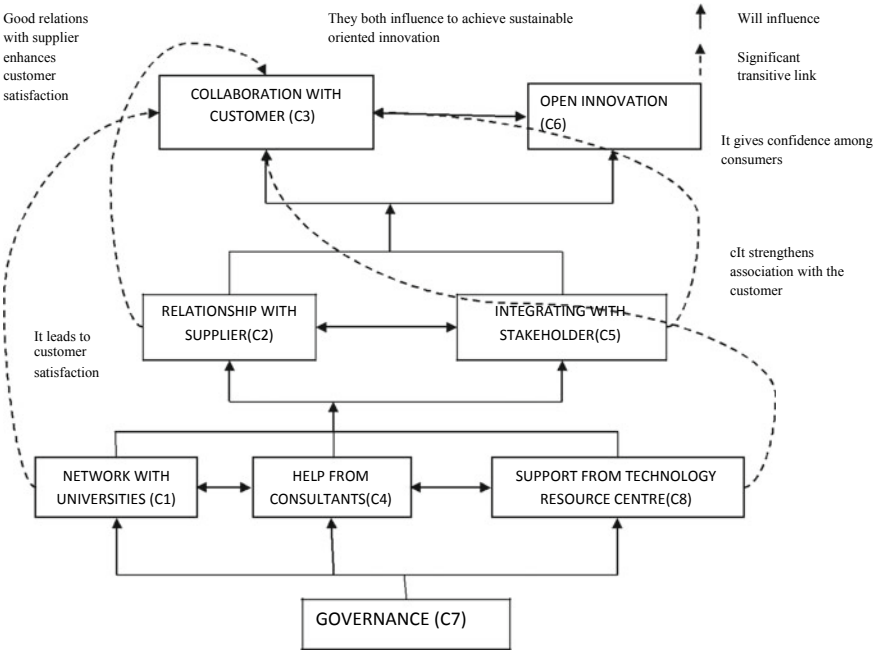


**Fig. 1** Total interpretive structural model

## 4 Results and Discussion

The present study aims at constructing a model between the critical factors affecting the sustainable-oriented innovation in Indian manufacturing MSMEs. The model is made using the TISM technique. The viewpoint of the experts is taken to make structural self-interaction matrix. The result of the technique is the model representing a structure of factors which influence the sustainable-oriented innovation in Indian manufacturing MSMEs.

## 5 Managerial Implications

This will help those MSMEs which are trying to move in the direction of sustainable-oriented innovation to recognise the parameters which need to be given more weight as they drive the other factors. The outcome of the present study can act as a catalyst in the drive towards sustainable-oriented innovation for the Indian manufacturing industries. The results can also be useful for organisations to identify the gaps and movement of information and resources among the industry professionals and the researchers and can work jointly on areas where the gap can be reduced in sustainability implementation.

## 6 Limitations of Study and Conclusions

This research attempts to explore the relationship between the critical factors that influence the implementation of sustainable innovated practices for Indian manufacturing meshes by constructing a model. A systematic study of the literature was conducted across various journals to find out the set of variables which influences in moving in the direction of sustainable-oriented innovation. After this, a model is made using TISM technique.

A major problem encountered was in identifying what can be included in the ambit of sustainable-oriented innovation for MSMEs considering the Indian perspective. Although an extensive review of the literature was performed to extract the variables, still many scopes exist for further refinement. Also, TISM has the constraint that it is a qualitative technique and it captures inaccuracy and ambiguity linked with the judgement of the experts.

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